Schoenocrambe suffrutescens (Shrubby Reed-mustard)

5-Year Review: Summary and Evaluation

Photo courtesy of Bekee Hotze, U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service
Utah Field Office – Ecological Services
West Valley City, Utah 84119

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5-YEAR REVIEW
Schoenocrambe suffrutescens (Shrubby reed-mustard)

1.0 GENERAL INFORMATION

1.1 Purpose of 5-Year Reviews

The U.S. Fish and Wildlife Service (USFWS) is required by Section 4(c)(2) of the Endangered Species Act (hereafter referred to as the "ESA") to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing as endangered or threatened is based on the species' status considering the five threat factors described in Section 4(a)(1) of the ESA. These same five factors are considered in any subsequent reclassification or delisting decisions. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process including public review and comment.

1.2 Reviewers

Lead Regional Office: Mountain-Prairie Regional Office (Region 6)
Bridget Fahey, Chief of Endangered Species, (303) 236-4258
Seth Willey, Recovery Coordinator, (303) 236-4257

Lead Field Office: Utah Ecological Services Field Office
Larry Crist, Field Supervisor, (801) 975-3330
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1.3 Methodology Used to Complete the Review

We initiated a 5-year review of *Schoenocrambe suffrutescens* (shrubby reed-mustard) on October 6, 2008 (73 FR 58261). We received no comments in response to the Federal Register (FR) notice. This review was completed by biologists from the Utah Ecological Services field office. It summarizes and evaluates information provided in the Utah Reed-Mustards Recovery Plan, current scientific research, and plant surveys. All pertinent literature and documents on file at the field office were used for this review. Interviews with individuals familiar with *S. suffrutescens* were conducted as needed to clarify or obtain specific information.

1.4 Background

1.4.1 Federal Register Notice Citation Announcing Initiation of Review

73 FR 58261, October 6, 2008

1.4.2 Listing History

Original Listing
FR notice: 52 FR 37416, October 6, 1987
Entity listed: Species
Classification: Endangered range-wide

1.4.3 Review History

On November 6, 1991, we initiated a 5-year review of all species listed prior to 1991 (56 FR 56882). This national notice summarized the status of all Threatened and Endangered species listed under the ESA prior to January 1, 1991, but did not further discuss species' status nor did it propose or change the status of any species, including *Schoenocrambe suffrutescens*. The status of *S. suffrutescens* was also considered in the 1994 Recovery Plan (discussed further below) (USFWS 1994).

1.4.5 Species' Recovery Priority Number at Start of 5-year Review

TABLE 1. Recovery Priority Number.

Degree of Threat	Recovery Potential	Taxonomy	Priority	Conflict
High	High	Monotypic Genus	1	1C
		Species	2	2C
		Subspecies/DPS	3	3C
	Low	**Monotypic Genus**	4	**4C**
		Species	5	5C
		Subspecies/DPS	6	6C
Moderate	High	Monotypic Genus	7	7C
		Species	8	8C
		Subspecies/DPS	9	9C
	Low	Monotypic Genus	10	10C
		Species	11	11C
		Subspecies/DPS	12	12C
Low	High	Monotypic Genus	13	13C
		Species	14	14C
		Subspecies/DPS	15	15C
	Low	Monotypic Genus	16	16C
		Species	17	17C
		Subspecies/DPS	18	18C

At the start of this 5-year review, the recovery priority number for *Schoenocrambe suffrutescens* was 4c. This ranking indicated: 1) populations face a high degree of threat; 2) recovery potential is low; and 3) the species is in conflict with construction or other development projects or other forms of economic activity. The current recovery priority number also indicates the species is a monotypic genus. This was based on the name *Glaucocarpum suffrutescens* (accepted by ITIS 2010 and USDA 2010). However, as noted below, we now feel it is premature to accept this taxonomic change (see sections 2.3.1.4 and 3.2 below).

1.4.5 Recovery Plan

Name of plan: Utah Reed-Mustards: Clay Reed-Mustard (*Schoenocrambe argillacea*), Barneby Reed-Mustard (*Schoenocrambe barnebyi*), and Shrubby Reed-Mustard (*Schoenocrambe suffrutescens*) Recovery Plan (hereafter referred to as the "Recovery Plan").

Date approved: September 14, 1994

2.0 REVIEW ANALYSIS

2.1 Application of the 1996 Distinct Population Segment Policy

This section of the 5-year review is not applicable to this species because the ESA precludes listing Distinct Population Segments (DPS) for plants. For more information, see our 1996 DPS policy (61 FR 4722, February 7, 1996).

2.2 Recovery Criteria

2.2.1 Does the species have a final, approved recovery plan?

Yes.

2.2.1.1 Does the recovery plan contain objective, measurable criteria?

Yes.

2.2.2 Adequacy of recovery criteria.

2.2.2.1 Do the recovery criteria reflect the best available and most up-to-date information on the biology of the species and its habitat? Are all of the 5 listing factors that are relevant to the species addressed in the recovery criteria (and is there no new information to consider regarding existing or new threats)?

Recovery criteria are no longer reflective of the best scientific information available. The Recovery Plan is 15 years old, and much of the information is now dated and inaccurate. Furthermore, the criteria do not consider or address all of the known threats. In addition, we need to reevaluate the recovery criteria target for achieving populations of 2,000 plants as we do not know if that constitutes a minimum viable population size.

Nevertheless, the species' status relative to these criteria are discussed below so as to show progress, or lack thereof, toward recovery.

2.2.3 List the recovery criteria as they appear in the recovery plan, and discuss how each criterion has or has not been met, citing information:

First Recovery Criterion: Discover or establish 5 populations of 2,000 or more individuals for downlisting and 10 populations of 2,000 or more individuals for delisting. These populations must be demonstrated to be at or above minimum viable population levels.

Status: The first demographic-based recovery criterion is not met. No comprehensive surveys of *Schoenocrambe suffrutescens* have occurred since 1994, when around 3,000 individuals were counted across the entire range (Franklin 1995). This estimate is far fewer than the 10,000 to 20,000 individuals recommended in the Recovery Plan. In addition, we have not yet determined a minimum viable population size for *S. suffrutescens*.

Second Recovery Criterion: Establish formal land management designations which would provide for long-term protection on undisturbed habitat.

Status: The second criterion is not met. No formal land management designations have been established to protect *Schoenocrambe suffrutescens* and its habitat.

2.3 Updated Information and Current Species' Status

2.3.1 Biology and habitat.

2.3.1.1 New information on the species' biology and life history.

Schoenocrambe suffrutescens is a perennial plant that grows in clumps from a branched, slightly woody stem. We do not know how long individual plants live and how often new individuals establish. Flowering for this species occurs in April to May and fruiting occurs May to June. Reproduction is sexual (USFWS 1994), and the species is capable of self-pollination (Tepedino 2000). However, seed set is lower in individuals that self-pollinate compared to individuals that are fertilized by pollen from another plant (Lewis 2010).

Range-wide pollinator studies were conducted for several rare intermountain species, including *Schoenocrambe suffrutescens* (Tepedino 2000). These results indicated *S. suffrutescens* was most likely not pollinator-limited (Tepedino 2000). However, recent research indicates that *S. suffrutescens* may be pollinator limited (Lewis 2010).

The following native bee species may be *Schoenocrambe suffrutescens* pollinators: *Dialictus perdifficilis, D. sedi, Evylaeus pulveris, Andrena walleye, A. prunorum* and *Halictus rubicundus* (USFWS 1994; Tepedino 2000; Lewis 2010). These species are small to medium-sized, mostly solitary bees (Bartlett et al. 2008; DiTerlizzi et al. 2008).

2.3.1.2 Distribution, abundance, and trends.

Schoenocrambe suffrutescens grows in an extremely limited band of soil derived from an upper member of the Green River geologic formation (USFWS 1994). This habitat is a disjunct white shale layer resembling small, dry desert islands (52 FR 37416, October 6, 1987) on level to moderate slopes (USFWS 1994). The factors governing the long-term population dynamics of *S. suffrutescens* are not well known (USFWS 1994). From 1935, when the species was first discovered, to 1987, when the species was listed, the population declined in size and range (USFWS 1994). The reasons for the decline are not well understood, but the practice of mining stone within occupied habitat was thought to be a major contributor, as was winter sheep grazing (USFWS 1994).

Schoenocrambe suffrutescens occurs in three areas in Uintah and Duchesne Counties:

(1) Gray Knolls Area -- This area is centered in the Gray Knolls between the Green River and Hill Creek, Uintah County and contains two populations including Dog Knolls and Gray Knolls.

(2) Pack Mountain Area -- This area is centered on Little Pack Mountain and the slopes of Big Pack Mountain between Hill Creek and Willow Creek, Uintah County and contains four populations including Agency Draw, Big Pack Mountain, Johnson Draw, and Thorn Ranch. Thorn Ranch is the type locality for the species, but is presumed extirpated.

(3) Badlands Cliff Area -- This area is at the base of the Badlands cliff above the Wrinkles Road, Duchesne County (USFWS 1994) and contains only the Badlands Cliff population.

We do not know if the three areas or if the seven populations are genetically isolated or if pollinators are able to travel between the areas or populations to ensure genetic diversity.

Figure 1 illustrates the approximate location of documented *Schoenocrambe suffrutescens* plants. The species' known geographic distribution has changed little since we began mapping its occurrences.

Figure 1 does not map suitable habitat. At present, suitable habitat survey data only exists for portions of one population (Buys and Associates 2007, 2008). Suitable, currently unoccupied habitats are important for population movement over time (Glisson 2005). Therefore, the future recommended actions section (see section 4.0 below) recommends collecting these data range-wide.

Landownership as a percent of the mapped population is presented in Table 2 below.

TABLE 2. Percent of the mapped *Schoenocrambe suffrutescens* populations by landowner.

LANDOWNER	TOTAL PERCENT OF MAPPED POPULATIONS
Bureau of Land Management (BLM)	62%
Uintah & Ouray Indian Reservation	21%
Private	10%
State School & Institutional Trust Land Administration (SITLA)	6%
TOTAL	100%

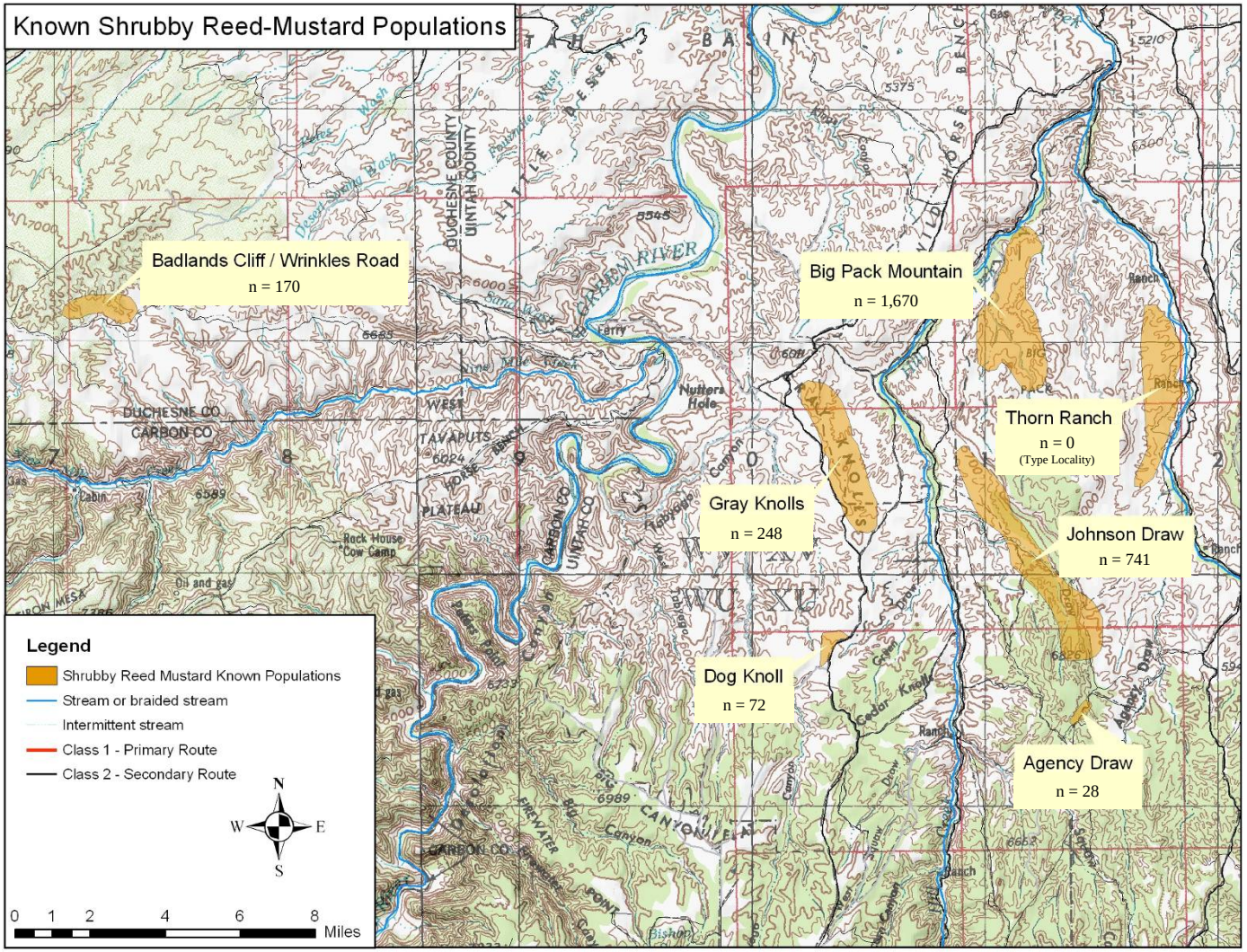

FIGURE 1. Known *Schoenocrambe suffrutescens* populations.

Note: Number of individuals derived from the most comprehensive survey for each of the populations.

A range-wide, comprehensive *Schoenocrambe suffrutescens* population survey was conducted in 1992 (Franklin 1992). Partial population surveys were conducted in 2004 and 2005 (Glisson 2004, 2005). We now estimate the species is limited to about 3,000 individuals within 3 areas and 7 populations. This estimate is lower than the 5,000 individuals provided in the 1994 recovery plan (USFWS 1994).

Schoenocrambe suffrutescens populations fluctuate greatly over time. For example, during the dry years between 2000 and 2003, *S. suffrutescens* plants were difficult to find (England pers. comm. 2008). More plants were found in 2006, a wetter year (Buys and Associates 2006b). While many plant species exhibit prolonged dormancy in response to drought (Kery et al. 2005), we do not know if *S. suffrutescens* exhibits this survival strategy. Similarly, Glisson (2005) observed a 50-percent reduction from 2004 to 2005 (Glisson 2005), but did not speculate on the cause.

2.3.1.3 Genetics, genetic variation, or trends in genetic variation.

No work has been done on the genetics of individuals or populations for *Schoenocrambe suffrutescens*. Taxonomically oriented phylogenetic studies have been conducted and are covered below in section 2.3.1.4.

2.3.1.4 Taxonomic classification or changes in nomenclature.

Schoenocrambe suffrutescens was first discovered in 1935 by Edward Graham, described by Reed Rollins as *Thelypodium suffrutescens* (Graham 1937), and, in 1938, renamed *Glaucocarpum suffrutescens* (Rollins 1938; 52 FR 37416, October 6, 1987). *Glaucocarpum suffrutescens* was listed as an endangered species under the authority of the ESA of 1973, as amended, on October 6, 1987 (52 FR 37416, October 6, 1987), under the name of toad-flax cress.

In 1985, the genus was formally changed from *Glaucocarpum* to *Schoenocrambe* (Welsh and Chatterley 1985). The species' common name was also changed from toad-flax cress to shrubby reed-mustard. In 1992, we published a final rule listing two other *Schoenocrambe* species (*S. argillacea* (Clay reed-mustard) and *S. barnebyi* (Barneby reed mustard)) which indicated we would begin to refer to this species by its scientifically accepted name *S. suffrutescens* (common name shrubby reed-mustard) (57 FR 1398, January 14, 1992).

In 2003, Porter (pers. comm., 2003, as cited in Buys and Associates 2006a) separated *S. suffrutescens* from other *Schoenocrambes* into *Glaucocarpum*. The name *Glaucocarpum suffrutescens* is the currently accepted scientific name for this species (ITIS 2010; USDA 2010). Most recently, Al-Shehbaz (2005) proposed re-establishing *Hesperidanthus* for

five of six *Schoenocrambes*, including *S. suffrutescens*, on the basis of molecular, cytological, and morphological data. This taxonomic change is not yet widely accepted, but has been accepted in the Flora of North America (Al-Shehbaz 2010).

Because this species' taxonomy remains unresolved, we are not recommending a name change at this time. We will continue to evaluate this species' taxonomy and will consider a name change within the next few years. Until this time, we will continue to refer to this species as *Schoenocrambe suffrutescens*.

2.3.2 Five-factor Analysis.

2.3.2.1 Present or threatened destruction, modification or curtailment of its habitat or range.

In the listing and Recovery Plan for *Schoenocrambe suffrutescens*, removal of building stone and localized grazing were associated with the decline in this species (52 FR 37416, October 6, 1987; USFWS 1994). Neither of these threats appear to be ongoing. The more pressing threat is that of energy development: the entire range of this species was leased for oil and gas development and is underlain by oil shale deposits (52 FR 37416, October 6, 1987; USFWS 1994; BLM 2008b).

Oil and Gas Development

Oil and gas resource development operations pose a significant threat to *Schoenocrambe suffrutescens* populations and habitat (USFWS 1990; 1994). All known populations of *S. suffrutescens* that occur on Federal lands are leased for oil and gas development (USFWS 1994). In addition, an ongoing natural gas project (currently in the first phase of development) overlaps the entire range of three of the known seven *S. suffrutescens* populations. These populations account for over 40 percent of the species' known suitable habitat and over 80 percent of all known individuals (USFWS 2008a).

The entire range of the species is underlain by oil shale, which may be mined when economically favorable (USFWS 1994). Because of economic constraints, significant commercial oil-shale production is unlikely within the next 20 years (USFWS 2006; BLM 2008).

Given the location of economically developable resources and a lack of protective land management designations, unchecked oil and gas development would, in the absence of the ESA, endanger the species' continued existence. ESA protections ensure mineral development avoids direct destruction of individual plants and occupied suitable habitat.

However, development continues in unoccupied suitable habitat, thereby limiting potential expansion and recovery of the species. Furthermore, development continues to occur in habitats immediately adjacent to occupied habitats. While steps have been taken to minimize these indirect effects, it is unknown if this adjacent development is adversely impacting the viability of *S. suffrutescens* populations. These indirect effects, and the protections currently provided, are discussed below.

***Habitat Fragmentation*:** *Schoenocrambe suffrutescens* exists in small, low-density populations that might be prone to negative effects from habitat fragmentation. For example, small plant populations fluctuate more widely over time and the smaller the remnant, the more susceptible the population is to extinction (Soulé et al. 1992; Forman and Alexander 1998; Menges 2002; Lienert 2004). Small plant populations can lose genetic variation and their population viability decreases (Ellstrand and Elam 1993; Lienert 2004; Kolb 2008). Fruit set, germination rate, offspring survival, and total numbers of flowers per plant are higher in larger populations than in small populations (Paschke et al. 2002). Similarly, the number of capsules per plant and the number of seedlings per plant are positively correlated with population size (Schmidt and Jensen 2000).

Roads associated with energy exploration and development cause a high level of habitat fragmentation. Increased oil and gas developments result in more roads developed in and near *S. suffrutescens* habitat. Ecological effects of roads to plants can extend more than 328 feet (100 meters) from the road (Angold 1997; Forman 2000; Forman and Deblinger 2000). Disturbance can occur directly from construction or indirectly from road dust, discussed further below (Farmer 1993; Angold 1997; Trombulak and Frissel 2000). There is a strong correlation between vegetation composition and health with distance from a road, although it may take decades for the full effects of road development to be realized (Auerbach et al. 1997; Myers-Smith et al. 2006).

***Road Dust*:** *Schoenocrambe suffrutescens* may be impacted by the indirect effects of road dust associated with oil and gas development. Road traffic mobilizes and spreads dust (Farmer 1993; Trombulak and Frissell 2000), and for every vehicle traveling 1 mile (1.6 kilometers) of unpaved roadway once a day, every day for a year, approximately 2.5 tons of dust are deposited along a 1,000-foot (~300-meter) corridor centered on the road (Sanders pers. comm. 2008). Dust deposition tends to be highest near the road and decreases with increasing distance from the road (Spatt and Miller 1981; Everett 1980; Walker and Everett 1987; Santelmann and Gorham 1988; Myers-Smith et al. 2006). For example, in one study 97 percent of dust was deposited within 410 feet (125 meters) of the road (Walker and Everett 1987). The distance from a road at which dust can

affect vegetation varies (see McCrea 1984; Myers-Smith et al. 2006), but negative impacts can occur up to 984 feet (300 meters) away from the road (Everett 1980).

Dust negatively affects photosynthesis, respiration, transpiration, water use efficiency, leaf conductance, growth rate, plant vigor, gas exchange, and allows the penetration of phytotoxic gaseous pollutants (Eller 1977; Spatt and Miller 1981; Thompson et al. 1984; Farmer 1993; Sharifi 1997; Trombulak and Frissell 2000; Hobbs 2001). Dust comprised of finer particulates was shown to cause more improper functioning of the stomata than larger particles (Ricks and Williams 1974; Eller and Brunner 1975; Eveling and Bataille 1984; Rawson and Clarke 1988; Hirano et al. 1995).

Clogged stomata result in increased water loss in two ways: due to an increased transpiration rate because of increased temperatures and due to clogged stomata that are unable to close at night (Hirano et al. 1995).

Other dust effects include inhibiting sunlight from reaching the surfaces of dusted plants (Sharifi et al. 1997). Additionally, a decrease in infra-red light reflectance can result in dusted leaves with a 4 to 5°F (2 to 3°C) higher temperature (Sharifi et al. 1997) compared to undusted leaves (Hirano et al. 1995). Soils near roads can have significantly lower nutrient levels, altered organic horizon depth, higher bulk density, and lower moisture (Auerbach et al. 1997). Furthermore, soil characteristics and plant community composition can remain significantly different up to 28 years after road development (Myers-Smith et al. 2006). We do not know if dust negatively affects plant pollinators.

One way to minimize road dust is to spray either calcium chloride or magnesium chloride on the road surface in addition to water, but these substances tend to increase salt accumulation in the soils adjacent to roads (Sanders and Addo 1993; Myers-Smith et al. 2006). Calcium chloride and magnesium chloride negatively impact plant health (Furniss pers. comm. 2009). Lignin-based dust suppressants may perform better than salts, but still negatively impact water quality from runoff (Sanders and Addo 1993). Slower vehicles reduce airborne dust. The relationship between speed and dust emissions is linear (Sanders and Addo 1993; Hobbs 2001). For instance, reducing vehicle speeds from 30 miles (48 kilometers) per hour to 15 miles (24 kilometers) per hour reduced dust emissions by 50 percent (Hobbs 2001).

The BLM implements a buffer of 300 feet (91 meters) for surface disturbance activities near *Schoenocrambe suffrutescens* occupied habitat and a requirement for monitoring of plants where surface disturbance occurs within the 300-foot (91-meter) buffer. Dust abatement (water only) is encouraged for construction activities within 300 feet (91 meters) of occupied habitat (USFWS 2008b).

***Plant-pollinator Interactions*:** Many of the negative effects of habitat fragmentation to plants are due to effects on plant-pollinator interactions (Debinski and Holt 2000; Moody-Weis and Heywood 2001; Aizen et al. 2002; Gathmann and Tscharntke 2002; Lennartsson 2002; Kolb 2008). Fragmented plant populations appear to be less attractive to insect pollinators, which spend more time in larger, unfragmented plant habitats (Aizen et al. 2002; Lennartsson 2002; Kolb 2008; Goverde et al. 2002). Furthermore, insect pollinator diversity increases in larger populations (Mustajarvi et al. 2001) and decreases in isolated habitats with smaller plant population sizes (Steffan-Dewenter and Tscharntke 1999). Lower pollinator visitation rates are associated with lower seed sets and reproductive success in fragmented sites compared to intact sites (Jennersten 1988).

Bumblebees were observed visiting more flowers on fewer flower stalks in sparser plant populations (Mustajarvi et al. 2001; Goverde et al. 2002). This led to increased self-pollination or near-neighbor pollination contributing to inbreeding (Goverde et al. 2002; Lennartsson 2002). Inbred plants produce fewer flowers and seeds, have smaller plant height and smaller leaf-size, and reduced reproductive success (Steffan-Dewenter and Tscharntke 1999; Lienert 2004; Kolb 2008).

Schoenocrambe suffrutescens pollinators are ground nesting, solitary bees (USFWS 1994; Tepedino 2000; Bartlett et al. 2008; DiTerlizzi et al. 2008; Tepedino pers. comm. 2008). Although *S. suffrutescens* fruit and seed set are not pollinator limited, further species-specific research is needed (Tepedino 2000).

Ground nesting bee species sometimes have specific nest site requirements, and human-caused habitat fragmentation changes native bee populations and species' composition due to alterations in nesting sites (Cane 2001). Nest sites are more often a limiting factor than pollen or nectar (Gathmann and Tscharntke 2002), and increased oil and gas development is likely to disturb nest sites for ground nesting bee species.

Tepedino (2000) recorded how far pollinators travelled for foraging, but he was unable to document foraging beyond 1,312 feet (400 meters) because of the small size of the bees over a large landscape. Within the foraging distance of 1,312 feet (400 meters) of mapped *Schoenocrambe suffrutescens*, there are currently 22 producing and permitted oil and gas wells (BLM GIS data, September 2009). Twenty of these wells are located in or within 1,312 feet (400 meters) of the northern portion of the mapped Big Pack Mountain population. Most of the energy related disturbance to date is concentrated in or near the largest population of

S. suffrutescens, with a large number of wells within known pollinator foraging distances. Studies to quantify the disturbance from continued energy development were initiated in 2009.

Overall, we believe energy related development can cause serious impacts to *Schoenocrambe suffrutescens* through habitat fragmentation, increased road dust, and disruption of plant-pollinator interactions. Current 300 feet (91 meters) buffers are likely adequate to minimize impacts to the species. Nevertheless, in 2009, we initiated studies to quantify the effects of continued energy development related to these factors.

Building Stone Mining

Schoenocrambe suffrutescens habitat is associated with commercially valuable building stone. Building stone mining can directly disturb individual plants and their habitat, with other effects similar to oil and gas development, including habitat fragmentation, increased dust, and pollinator disturbance.

Building stone mining was a significant historical threat to the species. Previous commercial stone excavation caused the extirpation of a portion of the species' population in the vicinity of Big and Little Pack Mountains (USFWS 1994).

Today, this factor is only a substantive issue on private land. Although approximately 57 percent of mapped *Schoenocrambe suffrutescens* populations on BLM lands are open to leasing (BLM GIS data, September 2009), building stone mining does not currently occur in occupied habitat on BLM land (Hansen pers. comm. 2009). Similarly, building stone is not currently mined on Uintah and Ouray Indian Reservation lands (Secakuku pers. comm. 2009), and is thus unlikely to impact *S. suffrutescens* on tribal lands in the immediate future.

On private lands, building stone is currently mined in *Schoenocrambe suffrutescens* occupied habitat. At one site, seven individual plants and occupied habitat were destroyed (Brunson 2010). We do not know how widespread this impact is across *S. suffrutescens* habitat on private lands.

With so few individuals of this species, we believe that the loss of any individuals could significantly impact the species. Therefore, based on recently documented disturbance on private lands, we believe that building stone mining remains a threat to this species.

Summary

Oil and gas development and the potential for oil shale development are the most significant threats to *Schoenocrambe suffrutescens*. In the absence of protection from the ESA, ongoing oil and gas development and potential future oil shale extraction could extirpate this species and destroy its habitat (52 FR 37416, October 6, 1987). Building stone mining was a significant historical threat to *S. suffrutescens*, and continues to threaten this species today.

2.3.2.2 Overutilization for commercial, recreational, scientific, or educational purposes.

In the listing and Recovery Plan for *Schoenocrambe suffrutescens*, overutilization was not known to be a threat to this species. No new information suggests overutilization for commercial, recreational, scientific, or educational purposes is a threat today.

2.3.2.3 Disease or predation.

According to both the listing and Recovery Plan for this species, sheep and cattle grazing may have had an historical impact. However, at current levels grazing is not expected to impact *Schoenocrambe suffrutescens* (USFWS 1994). Furthermore, the original listing also indicated wildlife grazing, particularly wild horses and rabbits, may adversely affect some populations of this species (52 FR 37416, October 6, 1987). A few individual plants were observed in the field with browsed branches, with several plants completely uprooted, presumably by grazers (Brunson 2009). At this time, the level of threat to *Schoenocrambe suffrutescens* from grazing and trampling is not known, but is not considered a meaningful factor impacting the viability of the species. Additional monitoring is recommended.

2.3.2.4 Inadequacy of existing regulatory mechanisms.

There were no Federal, state, or local laws or regulations that protected *Schoenocrambe suffrutescens* at the time of listing. When the Recovery Plan was written, only the protections of the ESA applied to this species. Below we analyze the current situation (i.e., the situation with ESA protections in place) and, in order to gauge the adequacy of regulatory mechanism, what would happen in the absence of ESA protections.

Federal Laws and Regulations

Land ownership within the mapped *Schoenocrambe suffrutescens* populations is predominantly BLM (Table 3). The remaining land owners include the Uintah and Ouray Indian Reservation, private landowners, and SITLA.

The National Environmental Policy Act (NEPA) (42 U.S.C. 4371 et seq.) provides some protections for listed species that may be affected by activities undertaken, authorized, or funded by Federal agencies. Prior to implementation of such projects with a Federal nexus, the NEPA requires an agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where the analysis reveals significant environmental effects, the Federal agency must discuss mitigation that could offset those effects (40 CFR 1502.16). These mitigations usually provide some protections for listed species. However, the NEPA does not require that adverse impacts be mitigated, only that impacts be assessed and the analysis disclosed to the public. In the absence of the ESA's protections, it is unclear what level of consideration and protection Federal agencies would provide through the NEPA process.

The ESA is the primary Federal law—and the only law at any level—that has protected *Schoenocrambe suffrutescens* since its listing in 1987. Section 7(a)(1) states that Federal agencies, in consultation with us, shall carry out programs for the conservation of endangered species. Section 7(a)(2) requires Federal agencies to consult with us to ensure any project they fund, authorize, or carry out is not likely to jeopardize the continued existence of listed species or modify their critical habitat. Section 9(a)(2) of the ESA prohibits the following activities: 1) the removal and reduction to possession (i.e., collection) of endangered plants from lands under Federal jurisdiction, and 2) the malicious damage or destruction on lands under Federal jurisdiction, and 3) the removal, cutting, digging, damaging, or destruction of endangered plants on any other area in knowing violation of a state law or regulation, or in the course of any violation of a state criminal trespass law. Section 9 also makes illegal the international and interstate transport, import, export, and sale or offer for sale of endangered plants and animals.

Through Section 7 consultation, conservation measures specifically addressing the protection of *Schoenocrambe suffrutescens* were included in the Utah BLM Resource Management Plan (USFWS 2008b). These protections will remain in place for the next 20 years (the life of the plan). An example of implementation of the conservation measures is the XTO Ltd. Little Canyon Project Area Natural Gas Development Project which included wells in suitable and occupied *S. suffrutescens* habitat. After more than 2 years of negotiating and working through the Section 7

consultation process, the applicant committed to conservation measures including avoidance or minimization of impacts, dust abatement, monitoring plans, and seed collection to mitigate seed bank loss (USFWS 2008a). Without the ESA, this development could have continued without protection for *S. suffrutescens*, which may have jeopardized the continued existence of the species.

Oil and gas development on the Uintah and Ouray Reservation is regulated by the Bureau of Indian Affairs (BIA) and the BLM. There are no tribal laws or regulations that provide protection to the species, but through the Federal nexus (in this case, the involvement of the BIA and BLM), protection is provided under the ESA. Without the ESA, we are aware of no regulatory mechanisms that would adequately protect the species on tribal lands.

State and Laws and Regulations

Utah has no state laws or regulations that protect *Schoenocrambe suffrutescens*.

Local or Other Laws and Regulations

There are no county or local laws or regulations protecting *Schoenocrambe suffrutescens*.

Summary

In the absence of the ESA's protection, there would be no regulations or laws at any level of jurisdiction to protect *Schoenocrambe suffrutescens*. With the level of proposed development in major population areas of this species (see section 2.3.2.1), loss of protection under the ESA would likely lead to extinction of this species.

2.3.2.5 Other natural or manmade factors affecting its continued existence.

At the time of listing, the only other natural or manmade factor thought to affect long-term survival of *Schoenocrambe suffrutescens* was small population sizes. Small populations remain a problem for this species, in addition to current impacts from habitat fragmentation, road dust, invasive species, and climate change. Most habitat fragmentation and road dust can be attributed to oil and gas development, and both are discussed at length in section 2.3.2.1 above. There are no data regarding the effects of invasive species and climate change specifically for *S. suffrutescens*. We include information from other species-specific studies to determine the most likely impacts to *S. suffrutescens*.

Small Populations

When *Schoenocrambe suffrutescens* was listed, it was known to occur in only nine populations with fewer than 3,000 individuals total, including three populations of fewer than 30 plants each. Recent estimates do not indicate significant changes. Small populations and species with limited distributions are vulnerable to relatively minor environmental disturbances (Given 1994). Small populations are also at an increased risk of extinction due to the potential for inbreeding depression, loss of genetic diversity, and lower sexual reproduction rates (Ellstrand and Elam 1993; Wilcock and Neiland 2002). Lower genetic diversity may, in turn, lead to even smaller populations by decreasing the species' ability to adapt, thereby increasing the probability of population extinction (Barrett and Kohn 1991; Newman and Pilson 1997).

Species with limited climatic ranges and restricted habitat requirements are typically the most vulnerable to extinction (Intergovernmental Panel on Climate Change [IPCC] 2002; Machinski et al. 2006). The risk of extinction is expected to increase for species with low population numbers (IPCC 2002; Jump and Penuelas 2005).

We lack information on the population genetics of *Schoenocrambe suffrutescens*. Recent observations indicate this species produces more seed when it is outcrossed (Lewis 2010). Therefore, the fewer plants are located at a site, the less chance for cross-fertilization. Because population numbers are very low for this species, we consider small population size a threat to *S. suffrutescens*, but without further research or information, we cannot predict the magnitude of this threat.

Invasive Species

Exotic species are common along highways because seeds are carried and deposited along roads by vehicles, and spread via vehicle-caused air turbulence (Forman and Alexander 1998). Roads promote the spread of invasive species by altering soil characteristics, stressing native vegetation, and providing easier movement by wild or human vectors (Trombulak and Frissell 2000). Spread of invasive species via roads coupled with increased road dust can exacerbate the impact on native species: an increase in fine dust particles can increase nonnative, exotic plant species (Reynolds et al. 2001).

Invasive, exotic plant species can contribute to the extinction of native plants (Soulé et al. 1992). Cheatgrass (*Bromus tectorum*) was documented in *Schoenocrambe argillacea* habitat (Glisson 2005), in the vicinity of the Big Pack Mountain *S. suffrutescens* population. Cheatgrass can out-compete native species for soil nutrients and water (Melgoza et al.

1990; Aguirre and Johnson 1991; Pyke and Novak 1994). If it establishes in sufficient density in native plant communities, cheatgrass increases flammability, leading to shortened fire return intervals that make it difficult for native plants to re-establish (D'antonio and Vitousek 1992). Halogeton (*Halogeton glomeratus*) has been documented growing in *S. suffrutescens* occupied habitat (Brunson 2009; Buys and Associates 2009, Lewis 2010). Halogeton quickly infests areas that are either left barren from fire or disturbed from mechanical or land management means (Pavek 1992). Halogeton tends to be a poor competitor, but it can accumulate sodium in the soil and alter soil microbiota to the disadvantage of native plants (Kitchen and Jorgensen 2001; Kitchen and Carlson 2008).

Although invasive species are present in *Schoenocrambe suffrutescens* habitat, they have not been noted at high levels. Their distribution is likely to increase over time as invasive annuals increase biomass and seed production at elevated levels of carbon dioxide (Mayeux et al. 1994; Smith et al. 2000; Ziska et al. 2005). Regardless, we do not consider invasive species a threat to *S. suffrutescens* now or for the foreseeable future.

Climate Change

Climate change is likely to affect long-term survival or distribution of native species. In the southwestern United States, including Utah and *Schoenocrambe suffrutescens* habitat, average temperatures have increased ~1.5°F (0.8°C) compared to a 1960-1979 baseline (Karl et al. 2009). By the end of this century, temperatures are expected to warm a total of 4 to 10°F (2 to 5°C) in the Southwest (Karl et al. 2009). Hot extremes, heat waves, and heavy precipitation will increase in frequency, with the Southwest experiencing the greatest temperature increase in the continental United States (IPCC 2007).

Throughout *Schoenocrambe suffrutescens*' range, precipitation is predicted to increase 10 to 15 percent in the winter and decrease 5 to 15 percent in spring and summer under the highest emissions scenario (Karl et al. 2009). Fall precipitation is predicted to stay the same (Karl et al. 2009). The levels of aridity of recent drought conditions and perhaps those of the 1950s drought years will become the new climatology for the southwestern United States (Seager et al. 2007). In fact, much of the southwest remains in a 10-year drought, "the most severe western drought of the last 110 years" (Karl et al. 2009, p. 130).

We do not know how changes in precipitation will affect *Schoenocrambe suffrutescens*. However, we do know that increased drought can be detrimental to many drought-tolerant species. Drought conditions led to a noticeable decline in survival, vigor and reproductive output of rare plants in the southwest during the drought years of 2001-2004 (Roth 2008a,

2008b; Clark and Clark 2007; Hughes 2005; Anderton 2002; Van Buren and Harper 2002, 2003). On the other hand, there is some indication that high-stress areas may contain plants that are adapted to that stressor, and drought-adapted species may experience lower mortality during severe droughts (Gitlin et al. 2006). Effects related to climate change, such as persistent or prolonged drought conditions, may affect the long-term persistence of *Schoenocrambe suffrutescens*, but without further research or information, it is difficult to predict how.

Summary

The effects of road dust (see Factor A) and small population size are likely to be a significant detriment to survival of *Schoenocrambe suffrutescens*. The effects of invasive species and climate change are more uncertain, and we cannot predict their effects on this species' survival without more information.

2.4 Synthesis

At the time of listing, we concluded that *Schoenocrambe suffrutescens* was endangered (i.e., in danger of extinction in all or a significant portion of its range) due to historical alteration of its habitat, potential oil and gas development, inadequacy of regulatory mechanisms, and small population sizes (52 FR 37416, October 6, 1987). Historical impacts (building stone collection and overgrazing) likely had the greatest effect on *S. suffrutescens* and its habitat, but these threats had essentially ceased by the time the species was listed.

Since listing, the threats of oil and gas development, stone building or mining of stone-building materials, and small population sizes remain. Oil and gas development throughout major portions of the species' habitat is planned, and without protection from the ESA, the species would likely be extirpated either from direct destruction or indirectly from the effects of road dust and habitat fragmentation. Because of Section 7 consultation processes under authority of the ESA, we have been able to work with BLM and energy development companies to survey for the species, delineate conservation areas, and approach oil and gas exploration and production in a phased approach. Mining of stone building materials remains a threat on private land. Small population sizes remain a concern with only 3,000 total individuals, and with 5 of the 7 known populations estimated at fewer than 250 individuals. No new populations have been found since listing. New potential threats from invasive species or climate change may exacerbate negative effects, but we need research that directly tests these questions.

Most of what we know of the species' distribution is from a survey completed over 10 years ago and a few partial surveys conducted on a case-by-case basis. Regular monitoring of the species across its entire range is needed to track the species' response to ongoing threats and population changes over time.

We conclude that *Schoenocrambe suffrutescens* should retain its classification as an endangered species throughout its range. The threats from potential oil and gas development are too great to warrant downlisting or delisting of this species.

3.0 RESULTS

3.1 Recommended classification:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
_X_ No change is needed

3.2 New recovery priority number: 5C

We recommend a change in recovery priority number for *Schoenocrambe suffrutescens* to 5c (see Table 1 above). This indicates a species facing a high degree of threat and a low recovery potential that is in conflict with economic development. Regarding the taxonomy, we no longer accept this species as a monotypic genus as the scientific community has not universally adopted *Glaucocarpum* as the genus for this species. Therefore, we feel it is premature to accept this taxonomic change. The high degree of threat is related to oil and gas development, stone-building material mining, and small population sizes (see 2.3.1.4, 2.3.2, and 2.4 above). Two of these threats put the species in conflict with construction or other development projects or other forms of economic activity (see 2.3.2.1). Additionally, the recovery potential for this species is low as the biological and ecological limiting factors are poorly understood, threats to the species are pervasive and difficult to alleviate, and techniques needed to recover the species are unknown.

4.0 RECOMMENDATIONS FOR FUTURE ACTIONS[1]

Surveys and Monitoring

- We recommend conducting range-wide, comprehensive surveys for *Schoenocrambe suffrutescens* within the next year, especially in the Gray Knolls area on tribal land. These data should be used to define and delineate populations, and to help revise the Recovery Plan.

[1] The Uinta Basin Rare Plant Forum—a group of private, government, and non-profit biologists—ranked *Schoenocrambe suffrutescens* as the highest priority for future studies (Uinta Basin Rare Plant Forum 2009). Most of the priorities identified by this group are captured here.

- Monitoring plots were established for testing plant response to disturbance, and basic demographic data are being collected. We recommend continuing to collect data from at least a portion of these plots indefinitely, even past the need for the disturbance study, to be able to answer basic demographic questions and to monitor reproduction.

Research

- The previous geological nomenclature that was commonly used to identify potential *Schoenocrambe suffrutescens* habitat was discarded (Weiss 1990), thus complicating an already difficult search for this species. We need to accurately characterize parent material, soil, and landscape characteristics for *S. suffrutescens*. This research would allow us to more accurately identify unoccupied but potentially important habitat, areas for focused surveys and reintroduction, and areas where oil and gas development are unlikely to harm the species.

- *Schoenocrambe suffrutescens* should be reintroduced to new areas of suitable but unoccupied habitat near existing populations.

- Basic biological and ecological information should be obtained for this species, including pollination mechanisms and pollinators. This research began in 2010.

- Studies to quantify the effects of dust, invasive species, and disturbance from continued energy development were initiated in 2009. These studies should be continued until we have enough data to draw conclusions.

- We should consider collecting seeds to include this species in the Center for Plant Conservation collection. Seeds should also be tested for viability and longevity.

Threats Abatement

- Nearly 40 percent of the mapped *Schoenocrambe suffrutescens* populations occur on non-Federal lands. We should continue to work with the Uintah and Ouray Indian Reservation, SITLA, and private landowners to survey and conserve *S. suffrutescens* habitat and increase outreach efforts.

- On Federal lands, we should continue to avoid development in *Schoenocrambe suffrutescens* populations and suitable, unoccupied habitat as much as possible, unless research becomes available to indicate that *S. suffrutescens* is unaffected by development. We should ensure that developers follow established conservation measures when disturbance occurs and that habitat fragmentation is reduced as much as possible.

- Using research collected on soil characteristics and response to disturbance, we should identify and establish core conservation areas in minimally-disturbed habitat

(both occupied and unoccupied) for long-term protection of *S. suffrutescens*.

Administrative Actions

- Once we have new survey data and research data available, we recommend revising the Recovery Plan to explicitly address the relevant listing factors. Time and cost required to meet the criteria and recover the species should be included in the Recovery Plan.

- We will continue to monitor the acceptance of *Hesperidanthus* as the correct genus for this species and will officially change this species' name through an FR notice as needed.

REFERENCES

Aizen, M.A., L. Ashworth, and L. Galetto. 2002. Reproductive success in fragmented habitats: do compatibility systems and pollination specialization matter? Journal of Vegetation Science 13:885-892.

Al-Shehbaz, I.A. 2005. *Hesperidanthus* (Brassicaceae) Revisited. Harvard Papers in Botany 10:47-51.

Al-Shehbaz, I.A. 2010. *Hesperidanthus*. In: Flora of North America Editorial Committee, eds. 1993+. Flora of North America North of Mexico. 16+ vols. New York and Oxford. Vol. 7, p. 689

Angold, P.G. 1997. The impact of a road upon adjacent heathland vegetation: effects on plant species composition. Journal of Applied Ecology 34:409-417.

Anderton, L. 2002. Summary of Spence's *Schoenocrambe barnebyi* Monitoring Plot, 1998-2001. Unpublished report prepared for the Capitol Reef National Park. 1 pp.

Auerbach, N.A., M.D. Walker, and D.A. Walker. 1997. Effects of roadside disturbance on soil and vegetation properties in arctic tundra. Ecological Applications 7:218-235.

Barrett, S.C.H., and J.R. Kohn. 1991. Genetic and evolutionary consequences of small population size in plants: implications for conservation. In Genetics and Conservation of Rare Plants, ed. DA Falk, KE Holsinger, pp. 3–30. New York: Oxford University Press.

Bartlett, T., P. Coin, H. Nendick-Mason, and B. Moisset. 2008. Family Halictidae – Sweat Bees-BugGuide.Net. Original contribution by Troy Bartlett on February 16, 2004; Additional contributions by Patrick Coin, Hannah Nendick-Mason, and Beatriz Moisset. Last updated September 16, 2008. [online] URL: http://bugguide.net.

Brunson, J. 2009. Personal observation and field notes, October 10, 2009. Botanist, U.S. Fish and Wildlife Service, Utah Field Office.

Brunson, J. 2010. Field notes, memorandum to file, October 18, 2010. Botanist, U.S. Fish and Wildlife Service, Utah Field Office.

Bureau of Land Management. 2008a. Record of Decision and Approved Resource Management Plan. BLM-UT-PL-09-003-1610, UT-080-2005-71. 201 pp. + appendices.

Bureau of Land Management. 2008b. Proposed Oil Shale and Tar Sands Resource Management Plan Amendments to Address Land Use Allocations in Colorado, Utah, and Wyoming and Final Programmatic Environmental Impact Statement. BLM, Washington, D.C. 8971 pp.

Buys and Associates. 2006a. Final Programmatic Biological Assessment of Barneby Reed-mustard (*Schoenocrambe barnebyi*), Clay Reed-mustard (*Schoenocrambe argillacea*), and Shrubby Reed-mustard (*Schoenocrambe suffrutescens*) on Utah Bureau of Land Management Lands. 65 pp.

Buys and Associates. 2006b. GIS Survey Data for Occupied Habitats for the shrubby reed-mustard.

Buys and Associates. 2007. GIS Survey Data for Suitable Habitats for the shrubby reed-mustard.

Buys and Associates. 2008. GIS Survey Data for Suitable Habitats for the shrubby reed-mustard.

Cane, J.H. 2001. Habitat Fragmentation and Native Bees: A Premature Verdict? Conservation Ecology 5(1): 3.

Clark, T.O., and D.J. Clark. 2007. *Sclerocactus wrightiae* monitoring in Capitol Reef National Park. Unpublished report prepared for the Capitol Reef National Park. 23 pp.

DiTerlizzi, T., B. Moiset, and J.S. Ascher. 2008. Family Andrenidae – Mining Bees – BugGuide.Net. Original contribution by Tony DiTerlizzi on July 18, 2004. Additional contributions by Beatriz Moisset and John S. Ascher. Last updated October 7, 2008.

Debinski, D.M., and R.D. Holt. 2000. Review: a survey and overview of habitat fragmentation experiments. Conservation Biology 14:342-355.

Eller, B.M. 1977. Road dust induced increase of leaf temperature. Environmental Pollution 13:99-107.

Eller, B.M., and U. Brunner. 1975. Der Einfluss von Strassenstaub auf die Strahlungabsorption durch Blatter. Archives der Meteorolgie, Geophysik, und Bioklimatologie, Series B. 23, 37-146.

Ellstrand, N.C., and D.R. Elam. 1993. Population genetic consequences of small population size: implications for plant conservation. Annual Review of Ecology and Systematics 24:217-242.

England, L. 2008. Personal communication. Botanist, U.S. Fish and Wildlife Service, Utah Field Office.

Eveling, D.W., and A. Bataille. 1984. The effect of deposits of small particles on the resistance of leaves and petals to water loss. Environmental Pollution 36:229-238.

Everett, K.R. 1980. Distribution and properties of road dust along the northern portion of the Haul Road. Pages 101–128 in J. Brown and R. Berg, editors. Environmental engineering and ecological baseline investigations along the Yukon River–Prudhoe Bay Haul Road. CRREL Report 80-19. U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire, United States of America.

Farmer, A.M. 1993. The effects of dust on vegetation–a review. Environmental Pollution 79:63-75.

Forman, R.T. 2000. Estimate of the area affected ecologically by the road system in the United States. Conservation Biology 14:31-35.

Forman, R.T., and L.E. Alexander. 1998. Roads and Their Major Ecological Effects. Annual Review of Ecology and Systematics 29:207-231.

Forman, R.T., and R.D. Deblinger. 2000. The ecological road-effect zone of a Massachusetts (U.S.A.) suburban highway. Conservation Biology 1:36-46.

Franklin, M.A. 1992. Report for 1991 Challenge Cost Share Project, U.S. Bureau of Land Management, Vernal District. Target Species: *Schoenocrambe argillacea* (Welsh and Atwood) Rollins. Utah Natural Heritage Program, Department of Natural Resources, Salt Lake City.

Franklin, M.A. 1995. Field Inventory of *Schoenocrambe suffrutescens* (R.C. Rollins) S.L. Welsh and L.M. Chatterley in the Book Cliffs Resource Area, Uinta Basin, Utah. Unpublished report prepared by the Utah Natural Heritage Program. Submitted to Bureau of Land Management, Vernal District, Utah. 9 pp. + appendices.

Furniss, S. 2009. Personal communication. Refuge program specialist. U.S. Fish and Wildlife Service Refuge System Headquarters.

Gathmann, A., and T. Tscharntke. 2002. Foraging ranges of solitary bees. Journal of Animal Ecology 71:757-764.

Gitlin, A.R., C.M. Sthultz, M.A. Bowker, S. Stumpf, K.L. Paxton, K. Kennedy, A. Muñoz, J.K. Bailey, and T.G. Whitham. 2006. Mortality gradients within and among dominant plant populations as barometers of ecosystem change during extreme drought. Conservation Biology 20:1477-1486.

Given, D.R. 1994. Principles and Practice of Plant Conservation. Timber Press, Inc., 133 SW Second Avenue, Suite 450, Portland, OR 97204-3527, viii & 292 pp. ISBN 0-88192-249-8.

Glisson, B. 2004. Interim Report by Bruce Glisson–Challenge Cost Share (Agreement Number JVA040004) Survey and Inventory for Summer 2004 of *Scoenocrambe suffrutescens* and *Schoenocrambe argillacea* for the BLM Vernal Field Office. 11 pp.

Glisson, B. 2005. Final Report by Bruce Glisson–Challenge Cost Share (Agreement Number JVA040004) Survey and Inventory for Summer 2005 of *Glaucocarpum suffrutescens* and *Schoenocrambe argillacea* for the BLM Vernal Field Office. 7 pp.

Goodman, D. 1987. The demography of chance extinction. Pages 11—34 in M.E. Soulè, editor. Viable populations for conservation. Cambridge University Press, Cambridge, England.

Gorrell, J.V., M.E. Andersen, K.D. Bunnell, M.F.Canning, A.G. Clark, D.E. Dolsen, and F.P. Howe. 2005. Utah Comprehensive Wildlife Conservation Strategy. Utah Division of Wildlife Resources Publication Number 05-19. Salt Lake City, UT. 280 pp.

Goverde, M., K. Schweizer, B. Baur, and A. Erhardt. 2002. Small-scale habitat fragmentation effects on pollinator behaviour: experimental evidence from the bumblebee *Bombus veteranus* on calcareous grasslands. Biological Conservation 104:293-299.

Graham, E.H. 1937. Botanical studies in the Uinta Basin of Utah and Colorado. Annals of the Carnegie Museum 26:1-432.

Hansen, R. 2009. Personal communication. Geologist, Bureau of Land Management, Vernal, UT.

Hirano, T., M. Kiyota, and I. Aiga. 1995. Physical effects of dust on leaf physiology of cucumber and kidney bean plants. Environmental Pollution 89:255-261.

Hobbs, M.L. 2001. Good practice guide for assessing and managing the environmental effects of dust emissions. Published September 2001 by Ministry for the Environment. P.O. Box 10-362, Wellington, New Zealand. 58 pp.

Hughes, L. 2005. An Update. Arizona Strip Rare Plant Monitoring and Inventory. Unpublished annual report prepared for the BLM AZ Strip District. 18 pp.

Integrated Taxonomic Information System. 2010. Retrieved January 20, 2010, from the Integrated Taxonomic Information System on-line database, http://www.itis.gov.

Intergovernmental Panel on Climate Change. 2002. Climate Change and Biodiversity. IPCC Technical Paper V. 74pp. + appendices.

Intergovernmental Panel on Climate Change. 2007. Fourth Assessment Report Climate Change 2007: Synthesis Report Summary for Policymakers. Released on November 17, 2007.

Jennersten, O. 1988. Pollination in *Dianthus deltoids* (Caryophyllaceae): effects of habitat fragmentation on visitation and seed set. Conservation Biology 2:359-366.

Jump, A.S., and J. Peñuelas. 2005. Running to stand still: adaptation and the response of plants to rapid climate change. Ecology Letters, Vol. 8:1010-1020.

Karl, T.R., J.M. Melillo, and T.C. Peterson, (eds.). 2009. Global Climate Change Impacts in the United States. Cambridge University Press.

Kery, M., K.B. Gregg, and M. Schaub. 2005. Demographic estimation methods for plants with unobservable life-states. Oikos 108:307-320.

Kolb, A. 2008. Habitat fragmentation reduces plant fitness by disturbing pollination and modifying response to herbivory. Biological Conservation 141:2540-2549.

Lennartsson, T. 2002. Extinction thresholds and disrupted plant-pollinator interactions in fragmented plant populations. Ecology 83:3060-3072.

Lewis, M. 2010. Annual report on *Shoenocrambe suffrutescens* research. M.S. student, Utah State University, Logan, UT. Report on file at Vernal BLM. 23 pp.

Lienert. J. 2004. Habitat fragmentation effects on fitness of plant populations – a review. Journal for Nature Conservation 12:53-72.

Machinski, J. J.E. Baggs, P.F. Quintana-Ascencio, E.S. Menges. 2006. Using population viability analysis to predict the effects of climate change on the extinction risk of an endangered limestone endemic shrub, Arizona cliffrose. Conservation Biology, Vol. 20(1):218–228.

Mayeux, H.S., H.B. Johnson, and H.W. Polley. 1994. Potential interactions between global change and intermountain annual grasslands. Paper presented at the symposium on "Ecology, Management, and Restoration of Intermountain Annual Rangelands," May 18-22, 1992, Boise, Idaho. General Technical Report INT 313:95–100.

McCrea, P.R. 1984. An assessment of the effects of road dust on agricultural production systems. Agricultural Economics Research Unit, Lincoln College, Canterbury.

Menges, E.S. 2002. Population viability analysis in plants: challenges and opportunities. TREE Review: PVA in Plants. 26 pp.

Moody-Weis, J., and J.S. Heywood. 2001. Pollination limitation to reproductive success in the Missouri evening primrose, *Oenothera macrocarpa* (Onagraceae). American Journal of Botany 88:1615-1622.

Mustajarvi, K., P. Siikamaki, S. Rytkonen, and A. Lammi. 2001. Consequences of plant population size and density for plant-pollinator interactions and plant performance. Journal of Ecology 89:80-87.

Myers-Smith, I.H., B.K. Arnesen, R.M. Thompson, and F.S. Chapin III. 2006. Cumulative impacts on Alaskan arctic tundra of a quarter century of road dust. Ecoscience. 13:503-510.

Newman, D., and D. Pilson. 1997. Increased probability of extinction due to decreased genetic effective population size: experimental populations of *Clarkia pulchella.* Evolution 51:354–362.

Paschke, M., C. Abs, and B. Schmid. 2002. Effects of population size and pollen diversity on reproductive success and offspring size n the narrow endemic *Cochlearia bavarica* (Brassicaceae). American Journal of Botany 89:1250-1259.

Pavek, D.S. 1992. *Halogeton glomeratus*. In: Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer).

Rawson, H.M., and J.M. Clarke. 1988. Nocturnal transpiration in wheat. Australian Journal of Plant Physiology 15:397-406.

Reynolds, R., J. Belnap, M. Reheis, P. Lamothe, and F. Luiszer. 2001. Aeolian dust in Colorado Plateau soils: Nutrient inputs and recent change in source. PNAS. 98:7123-7127.

Ricks, G.R., and R.J.H. Williams. 1974. Effects of atmospheric pollution on deciduous woodland. 2. Effects of particulate matter upon stomatal diffusion resistance in leaves of *Quercus petraea* (Mattuschka) Liebl. Environmental Pollution 6:87-109.

Rollins, R.C. 1938. *Glaucocarpum*, a new genus in the Cruciferae. Madroño 4:232-235.

Roth, Daniela. 2008a. Monitoring Report, *Pediocactus bradyi*, Marble Canyon, Coconino Co., Arizona. Unpublished report prepared for the Navajo Natural Heritage Program, Window Rock, AZ. 9 pp.

Roth, Daniela. 2008b. Monitoring Report, *Sclerocactus mesae-verdae* Transplant Project Northern Navajo Fairgrounds, Shiprock, San Juan County, New Mexico. Unpublished report prepared for the Navajo Natural Heritage Program, Window Rock, AZ. 8 pp.

Sanders, T.G., and J.Q. Addo. 1993. Effectiveness and environmental impact of road dust suppressants. MPC-94-28. Fargo, North Dakota: Mountain Plains Consortium.

Sanders, T.G. 2008. Personal communication. Associate Professor, Civil and Environmental Engineering, Colorado State University, Fort Collins.

Santelmann, M.V., and E. Gorham. 1988. The influence of airborne road dust on the chemistry of Sphagnum mosses. Journal of Ecology 76:1219-1231.

Schmidt, K., and K. Jensen. 2000. Genetic structure and AFLP variation of remnant populations in the rare plant Pedicularis palustris *(Scrophulariaceae)* and its relation to population size and reproductive components. American Journal of Botany 87:678-689.

Seager, R., T. Mingfang, I. Held, Y. Kushnir, J. Lu, G. Vecchi, H. Huang, N. Harnik, A. Leetmaa, N. Lau, C. Li, J. Velez, and N. Naik. 2007. Model projections of an imminent transition to a more arid climate in southwestern North America. Science 316:1181-1184.

Secakuku, B. 2009. Personal communication. Realty specialist, Bureau of Indian Affairs, Fort Duchsene, UT.

Sharifi, M.R., A.C. Gibson, and P.W. Rundel. 1997. Surface Dust Impacts on Gas Exchange in Mojave Desert Shrubs. Journal of Applied Ecology 34:837-846.

Shultz, L.M., and K.M. Mutz. 1979. Threatened and endangered plants of the Willow Creek drainage. Submitted to Bureau of Land Management, Vernal District, Utah. Miiji Resource Consultants, Logan, Utah. 74 pp. + maps and data sheets.

Silvertown, J., and D. Charlesworth. 2001. Introduction to plant population biology, 4th ed. Blackwell Publishing, Malden, MA, USA. 347 pp.

Soulé, M.E., A.C. Alberts, and D.T. Bolger. 1992. The effects of habitat fragmentation on chaparral plants and vertebrates. Oikos 63:39-47.

Smith, S.D., T.E. Huzman, S.F. Zitzer, T.N. Charlet, D.C. Housman, J.S. Coleman, L.K. Fenstermaker, J.R. Seeman, and R.S. Nowak. 2000. Elevated CO2 increase productivity and invasive species success in an arid system. Nature 408:79–81.

Spatt, P.S., and M.C. Miller. 1981. Growth conditions and vitality of sphagnum in a tundra community along the Alaska Pipeline Haul Road. Arctic 34:48-54.

Steffan-Dewenter, I., and T. Tscharntke. 1999. Effects of habitat isolation on pollinator communities and seed set. Oecologia 121:432-440.

Tepedino, V.J. 2000. The Reproductive Biology of Rare Rangeland Plants and Their Vulnerability to Insecticides in Grasshopper Integrated Pest management User Handbook (Gary L. Cunningham and Mike W. Sampson, tech. cords.). Technical Bulletin 1809. Washington, D.C.: USDA, APHIS: III.5-1 to III.5-10.

Tepedino, V. 2008. Personal communication. Professor emeritus, Department of Biology, Utah State University, Logan.

Thompson, J.R., P.W. Mueller, W. Fluckiger, and A.J. Rutter. 1984. The effect of dust on photosynthesis and its significance for roadside plants. Environmental Pollution 34:171-190.

Trombulak, S.C., and C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

Uintah Basin Rare Plant Forum. 2009. Meeting Notes, July 9, 2009, compiled by Joan Degiorgio, The Nature Conservancy, Salt Lake City. 3 pp.

U.S. Department of Agriculture, NRCS. 2010. The PLANTS Database (http://plants.usda.gov, January 20, 2010). National Plant Data Center, Baton Rouge, LA 70874-4490 USA.

U.S. Fish and Wildlife Service. 1990. *Schoenocrambe argillacea*: supplemental status report. Salt Lake City, UT. 3 pp.

U.S. Fish and Wildlife Service. 1994. Utah reed-mustards: clay reed-mustard (*Schoenocrambe argillacea*), Barneby reed-mustard (*Schoenocrambe barnebyi*), shrubby reed-mustard (*Schoenocrambe suffrutescens*) Recovery Plan. Denver, CO. 22 pp.

U.S. Fish and Wildlife Service. 2006. Endangered and Threatened Wildlife and Plants; Withdrawal of Proposed Rule to List *Penstemon grahamii* (Graham's beardtongue) as Threatened With Critical Habitat. Federal Register: December 19, 2006, Volume 71, Number 243.

U.S. Fish and Wildlife Service. 2008a. Biological Opinion on the Little Canyon Project Area Natural Gas Development Project proposed by XTO. FWS/R6, ES/UT, 6-F-0309, 6-UT-09-F-003. 51 pp.

U.S. Fish and Wildlife Service. 2008b. Programmatic Biological Opinion for BLM Resource Management Plan, Vernal Field Office. FWS/R6, ES/UT, 08-F-0057, 6-UT-08-F-0025. 121 pp.

Van Buren, R., and K.T. Harper. 2002. 2001 Status Report *Lesquerella tumulosa*. Kodachrome Bladderpod Demography. Order No. JC-POO-3015A. 9 pp + appendices.

Van Buren, R., and K.T. Harper. 2003. Demographic and environmental relations of two rare *Astragalus* species endemic to Washington County, UT: *Astragalus holmgreniorum* and *A. ampullarioides*. Western North American Naturalist 63:236-243.

Walker, D.A., and K.R. Everett. 1987. Road dust and its environmental impact on Alaskan Taiga and tundra. Arctic and Alpine Research 19:479-489.

Weiss, M.P., I.J. Witkind, and W.B. Cashion. 1990. Geologic map of the Price 30' x 60' Quadrangle, Carbon, Duchesne, Uinta, Utah, and Wasatch Counties, Utah: U.S. Geological Survey IMAP 1981.

Welsh, S.L., and L.M. Chatterley. 1985. Utah's rare plants revisited. Great Basin Naturalist 45:173-230.

Wilcock, C., and R. Neiland. 2002. Pollination failure in plants: why it happens and when it matters. Trends in Plant Science Vol. 7 (6):270–277.

Ziska, L.H., J.B. Reeves III, and B. Blank. 2005. The impact of recent increases in atmospheric CO2 on biomass production and vegetative retention of cheatgrass (*Bromus tectorum*): implications for fire disturbance. Global Change Biology 11:1325–1332.

Zouhar, K. 2003. *Bromus tectorum*. In Fire Effects Information System. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer).

U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW of *Schoenocrambe suffrutescens*

Current Classification: Endangered range-wide

Recommendation resulting from the 5-Year Review:

____ Downlist to Threatened
____ Uplist to Endangered
____ Delist
__X__ No change needed

Review Conducted By: Jessi Brunson, Botanist, Utah Ecological Services Field Office

FIELD OFFICE APPROVAL:

Lead Field Supervisor, Fish and Wildlife Service

Approve: _____ Date: 11/2/10

REGIONAL OFFICE APPROVAL:

Approve: _____ Date: 11/8/10
Regional Director, Region 6